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AEROPLANES

SO graceful and so effortless is the flight of large birds that for centuries men have sought to emulate their journeys through the air. The idea of winged flight obsessed even Leonardo da Vinci (1452–1519). Later inventors improved on his plans, built kites and gliders of their own, and even built a flying machine powered by steam. But none really flew. It needed the tenacity of Orville and Wilbur Wright and the power of the petrol engine to produce a successful aeroplane – this aeroplane first flew in 1903.

Since then there have been great changes. The 'tail-first' plane has given way to the rear tail unit, and the biplane has given way to the monoplane. Pusher airscrews have been replaced by tractor propellers, and these in their turn have been largely superseded by gas turbines.

Instead of tiny aircraft barely able to lift a man, there are vast airliners capable of carrying 200 people over stage lengths of 6,000 miles.

Let us first look at some of the famous aircraft of today; then at the means by which these aircraft fly.

Five modern military aircraft

THE HUSTLER – The aptly named American delta-wing bomber, the B58, is capable of Mach 2·0 (twice the speed of sound). Such speed is the result of fitting four turbojet engines, each of 15,600 pounds thrust, into a relatively small aircraft of excellent aerodynamic shape.

An interesting feature of the Hustler is the disposable pods carried beneath the slim fuselage. The lower unit contains fuel, the upper is large enough to carry a nuclear bomb.

THE HAWKER P1127 – This VTOL (vertical take-off and landing) aircraft first flew in 1960. Its Pegasus jet engines have swivelling nozzles, which, by directing the jets downwards, enable the aircraft to rise vertically from the ground. When the aircraft is airborne the nozzles slowly turn to direct the efflux rearwards, and in this way forward flight is achieved.

A development of the 1127, the Hawker P1154, will have a maximum speed exceeding Mach 1·0.

THE LIGHTNING – This all-weather day and night interceptor is unusual in that its two engines are staggered one above the other in the fuselage. With re-heat they provide sufficient thrust to propel the Lightning at Mach 2·0 in level flight. It is possible for this aircraft to cruise on a single engine and thus considerably increase its endurance in the air.

The thin wings have leading edges swept back at 60°, an arrangement which requires the ailerons to be fitted to the tips of the wings instead of to the trailing edges.

THE VULCAN – Unusual in appearance, this delta-wing aircraft is one of the V-bomber types used by the Royal Air Force. For its size the Vulcan possesses quite remarkable manœuvrability, a feature which has been excitingly demonstrated at Farnborough Air Displays. Its ability to roll, and to climb vertically and then roll off the top, was expertly demonstrated by the manufacturer's test pilots.

The version of this bomber known as the Vulcan B Mark 2 is equipped to carry the Blue Steel stand-off bomb.

In these five military aircraft the power of jet engines is used to provide speed for a surprise attack and a safe return to base

Previous page: Leonardo da Vinci studying his model of a spring-operated wing. *Above:* The Curtiss *June Bug* aircraft (1908). A Fokker D VII fighter scout (1918). A Saab-35A *Draken* (1960). An artist's idea of a Mach 3·0 airliner.

These illustrations are not drawn to a uniform scale

A view across the busy dockyards of Barcelona, Spain's principal port

SPAIN is a colourful and exciting country, cut off from the rest of Europe by the Pyrenees, and quite unique in atmosphere. Her people are proud, upholding the traditions and code of manners practised for centuries. During her history (see pages 838–839) Spain has been invaded and settled by the Romans, Visigoths, Arabs, and French, all of whom have contributed to the Spanish character and way of life. Their fortified cities, churches, and villas still stand, as much a part of modern Spain as the new steel works and textile mills (see Economy of Spain, pages 1508–1509). Every province and city has a sparkling vitality that is unmistakably Spanish, expressed as much in the architecture of the cities as in the colourful festivals and dances of the people.

The economic capital

Barcelona is the capital of Catalonia and the second largest city in Spain, with 1,558,000 inhabitants (1960). Madrid (see page 814) is the political capital of Spain, but Barcelona is the commercial and industrial centre, with a well-equipped modern seaport, textile mills, chemical factories, and metal-works.

The city lies on a flat, sandy plain flanked by high sandstone cliffs and straggles up the slopes of the hills behind. The hillside suburb of Montjuich is laid out with beautiful parks and gardens, and Mount Tibidabo (1,745 feet) overlooks the bay.

Barcelona is over 2,000 years old, with a university founded in 1450. To the south of the well-planned modern quarter, with its broad avenues and flower-filled gardens, lies the old city with narrow, winding streets. Many churches and palaces, built between the 10th and 15th centuries, still stand. This was the capital of the kings of Aragon from the 12th century onwards, and Catalan, a dialect similar to that of Provence (France), is still widely spoken.

CITIES OF SPAIN

City of El Cid

Valencia (population 505,000) is perhaps the gayest city in Spain, famous for its flower market and lively fiestas. Valencia's old city, founded by the Romans in the 2nd century B C, is full of monuments to her changing history. The Moorish influence can be seen in the blue and white domed churches, formerly mosques, and the remarkable Miguelete bell tower, 152 feet high. The city has been the scene of many battles – the great El Cid recaptured Valencia from the Moors in 1094 – but little of the old fortifications remains. Valencia's university was founded in about 1500. Fruit, oil, wine, perfumes, and lace are all exported from this, the second largest port, as well as the products of its heavier industries.

The impressive fortress at Valencia, built in the 15th century

Above Segovia towers the Alcazar, a turreted citadel begun by the Moors in the 11th century

CITY OF THE PAST

Segovia (population 33,000) is built on a hill in Old Castile overlooking the bare Meseta. The Roman aqueduct with 70 arches still brings water to the city, which is dominated by a 16th-century Gothic cathedral. Within the city walls are treasures of every architectural period.

CORDOBA

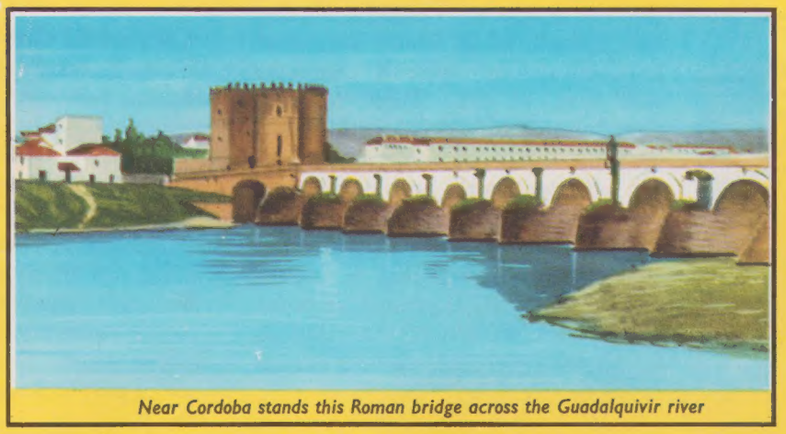
Many great men are linked with Cordoba. Caesar and Pompey fought here; Seneca, Lucan, and Averroës were among its citizens. It was the cultural centre of the Moorish empire; the Mesquita mosque (now a cathedral) is the finest in Spain, famous for its hundreds of columns. Today Cordoba (population 198,000) is the commercial centre of the fertile region of Andalusia. Industry and agriculture thrive side by side, including the traditional Moorish crafts of gold-, silver-, and leather-work.

Toledo: the magnificent cathedral contains some of El Greco's finest work

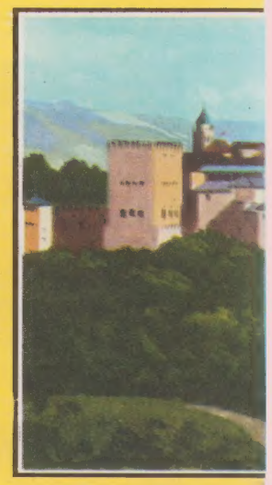
Bilbao is the foremost

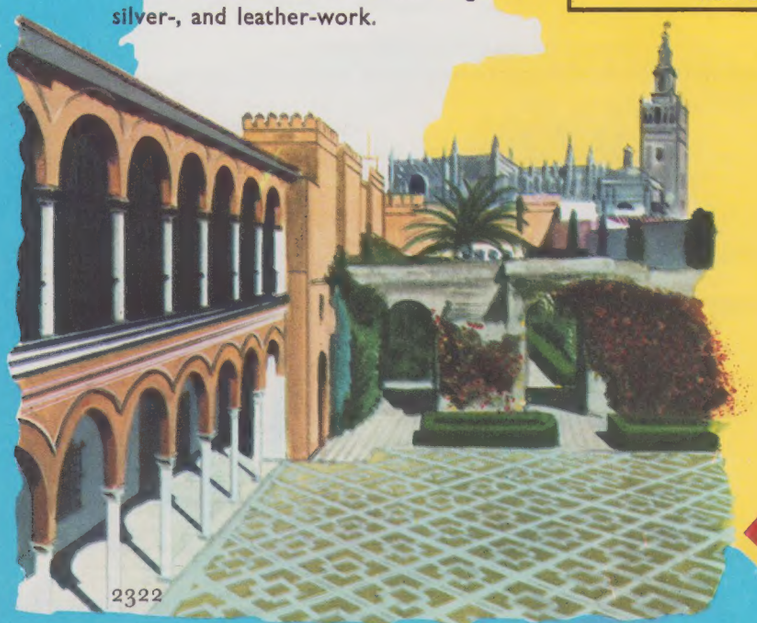
TOLEDO

Toledo (population 41,000), the Spanish capital from the 11th to 16th centuries and the home of El Greco, has always been famous for swords and retains its Moorish character.



Near Cordoba stands this Roman bridge across the Guadalquivir river





CITY OF FLOWERS AND FIESTAS

Seville is just as you would imagine a Spanish city to be – sunny, gay, and full of flowers. The single-storey whitewashed houses have patios or balconies; flowers tumble over the walls into streets that often resound with the music of gay fiestas (such as the annual *Feria*) or religious processions (as in Holy Week). Seville (population 443,000) is Spain's major inland port, connected to the sea by the Guadalquivir river and linked to the other cities by railway. It exports the produce of Andalusia, particularly oranges, as well as manufactured goods, textiles, and glassware.

The cathedral, begun in 1402, is the world's largest Gothic building and contains many paintings by great Spanish artists like Murillo (who lived in Seville) and El Greco. Nearby stands the Giralda, a Moorish minaret over 300 feet high, built when Seville was the capital of an Arab kingdom.

Seville: the 15th-century cathedral and the Giralda minaret (right) seen from the Alcazar garden

iron- and steel-producing town in Spain

BILBAO (population 298,000) is set on a deep inlet of the Bay of Biscay. It has been famous since the Middle Ages for iron and steel, and still exports large quantities, particularly to Britain. As well as an important shipyard, iron mines, an oil refinery, and chemical works, there are olive groves and vineyards on the slopes of the surrounding hills.

The harbour at Santander

Granada: on the Alhambra hill stands the Generalife palace (left) amid beautiful gardens, and the famous Arab fortress (right)

CITY OF THE POMEGRANATE

Granada (population 157,000) lies like an open pomegranate (its symbol) over three hills beneath the Sierra Nevada. The last stronghold of the Moors before their defeat by the Christian kings in 1492, Granada is still north African in character, dominated by the magnificent 13th-century Alhambra fortress. Charles V, the Holy Roman Emperor, also had a palace on Alhambra hill; it was begun in 1526 but never finished. The Albaicin hill is now the home of gypsy cave-dwellers whose flamenco dancing is one of the many tourist attractions. The Moorish arts of iron-, copper-, and leather-work, rug-making, and tapestry are still practised and form a great part of Granada's exports.

OTHER IMPORTANT CITIES

SARAGOSSA (population 326,000) is the principal city of Aragon, in north-east Spain, and a cultural centre, with a university (dating from 1474), academies, and museums. Saragossa existed before the Romans came to Spain, and is situated on the Ebro river in the midst of barren plains. Artificial irrigation has transformed it into an oasis (*huerta*) with vineyards, cornfields, and olive groves. There are two cathedrals, La Seo (12th-century), and El Pilar (17th-century) which contains murals by Goya, a castle, and several palaces and villas, all containing artistic treasures and paintings.

MALAGA (population 301,000) is known as the 'garden city of Andalusia', and is famous for the sweet Malaga wine. It is a leading tourist resort on the south coast, as well as an industrial centre and the port for Granada. Roman and Moorish buildings can still be seen, but this is essentially a modern city.

MURCIA (population 250,000) is the hottest place in Spain; it also suffers from sudden torrential rains and floods. It is in one of the richest garden areas and silk culture is its traditional industry.

The old city, containing the university, is surrounded by modern suburbs. Murcia was twice capital of an Arab kingdom.

JEREZ DE LA FRONTERA (population 131,000) in Andalusia is the centre of a great wine-making area and produces cognac and the famous sherry named after it. This rich and beautiful city, originally a Phoenician settlement, later captured by the Moors, has many historic buildings.

CARTAGENA (population 124,000) commands a deep bay guarded by fortresses. Founded in the 3rd century B C by Hannibal's brother Hasdrubal, it has always been an important naval and military port, with extensive shipbuilding yards.

SANTANDER (population 118,000) is a commercial and industrial port on the north coast. The old city contains a 13th-century Gothic cathedral; the new quarter is a popular resort, and the prehistoric cave paintings at nearby Altamira also attract tourists.

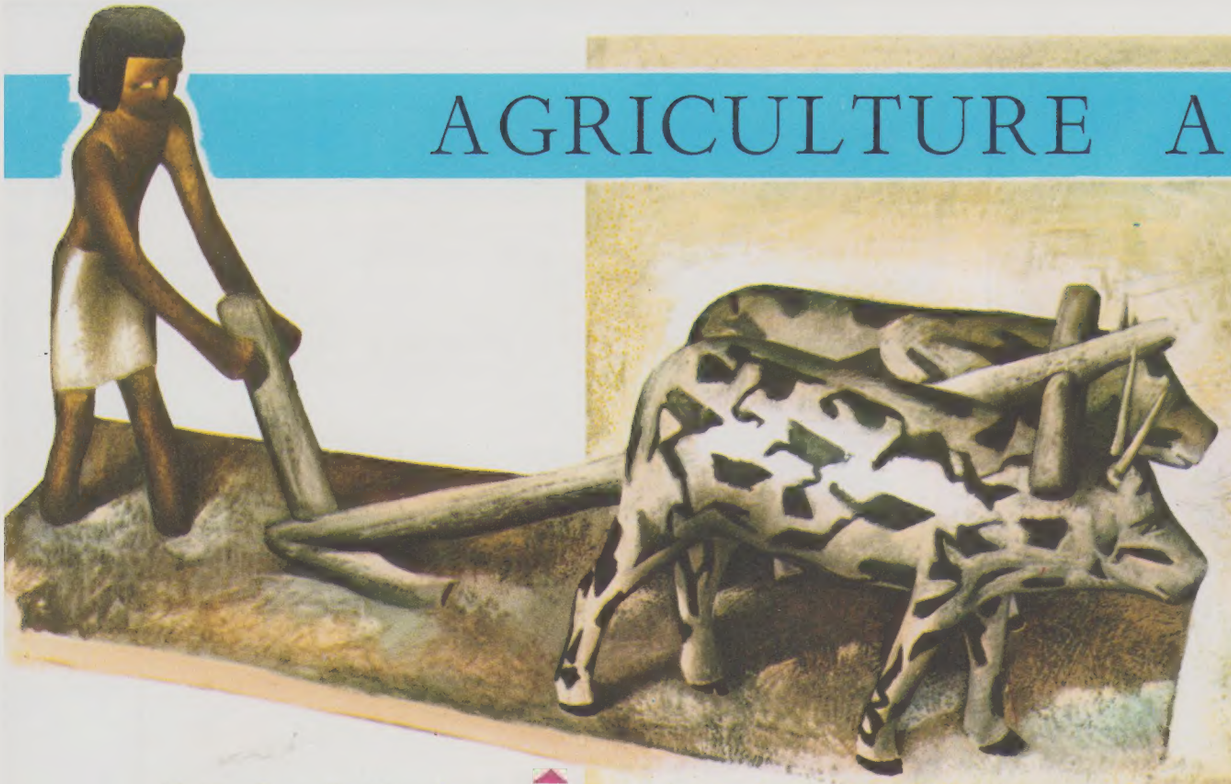
CADIZ (population 118,000) is an eye-catching city built on a headland that juts far out to sea. Since the Phoenicians settled here in 1100 B C, Cadiz has always been an important port and naval base; but it reached the peak of its prosperity when trade with the New World began. Its permanently warm climate makes it a popular resort. The Torre de Vigia (watch-tower) stands guard over the cheerful palm-lined streets and white, sun-baked houses.

SALAMANCA (population 90,000) has some of the most beautiful architecture in Spain. A Roman bridge crosses the Tormes river, but much of the city is in Gothic style, built from the 13th century onwards. Salamanca university was founded in about 1243.

AVILA (population 53,000) is mediaeval in character, perched on a ridge and still surrounded by the 13th-century fortifications – 1½ miles of walls with 86 towers. Since the 17th century its economic importance has declined.

VIGO (population 24,000) has a flourishing fishing industry. Set on a hillside overlooking a large natural harbour, Vigo has many historic buildings, as well as fine beaches. Ships from all over the world call here.

AGRICULTURE AND INDU



Model of an Egyptian farmer using an ox-drawn plough, about 2000 B C
(British Museum)

'EGYPT is the gift of the Nile,' wrote the Ancient Greek historian Herodotus. Without the Nile Egypt could not exist; one twenty-fifth of the country is fertile river valley, and the rest is barren desert. Every year rains in the Abyssinian mountains cause the waters of the Nile to rise and overflow their banks, spreading a thin layer of rich black soil over the flooded land.

The fertility of the Nile valley made possible in Egypt one of the earliest of civilisations (see page 2120). In Neolithic times farmers were living in settled communities in the valley, and by 4000 B C they were using copper to supplement stone for making their agricultural tools. By 3000 B C the various Nile tribes had united into one kingdom under the rule of the pharaohs. Egypt rapidly became the granary of the ancient world, supplying Syria and Mesopotamia as it was later to supply the needs of the Roman Empire. Wheat was grown to make bread, and barley was used for making beer. Vineyards were cultivated, and the Ancient Egyptians knew how to make wine. One of their major occupations was bee-keeping, and honey was produced in large quantities.

FARMING IN ART

Many Ancient Egyptian paintings and carvings that exist today show people working on the land. On this page are several Egyptian paintings showing ploughing, sowing, and reaping scenes.

The peasant farmers used a simple plough – a hoe tied to a pole and pulled by a team of oxen – to turn over the soil which was free from grass and stones. First of all the seed was scattered and was then ploughed into the

Ancient Egyptian wall-paintings showing ploughing, seed-sowing, and harvesting. At the bottom is the grape harvest

STRY IN ANCIENT EGYPT

In this wall-painting grain is being threshed by driving oxen over it. This separates the grain from the husks

Peasants digging the soil with simple picks

soil. Wheat, barley, and millet were the most important cereals grown. Harvest was a busy time. The grain ripened first in southern Egypt, and later in the Nile Delta, so farm labourers were transported by river from one area to another as they were needed. At first stone sickles were used for reaping, but later these were replaced by copper and bronze ones. The heads of grain were cut off, leaving the long stubble as good grazing for cattle.

The Egyptians grew a wide variety of vegetables – leeks, onions, lettuces, peas, beans, radishes, and cucumbers – and fruit such as melons, dates, figs, and apples (introduced from Asia). Vegetable oils were used for lighting, cooking, cosmetics, and medicine.

In spite of this variety of foods, cereals remained the most important, and large quantities were stored in granaries which could be tapped if the year's crop was a poor one. This might happen if there was an unusually low flood, or if the crop was destroyed by locusts. We are reminded of the pharaoh's dream of 'seven lean years' in the Bible.

The Egyptians made wine from grapes and dates, and the vintages were carefully recorded on the wine jars.

Scribes recording the amount of grain stored in a granary

PAPER AND TEXTILES

Papyrus rushes grew in the Nile Delta and in upper Egypt, and were used as food, for making cord, and, most important of all, for making writing paper. This was done by taking lengths of the pith from the stem of the papyrus reed, covering it with a second layer at right angles, and hammering the two together with a mallet. The result was the first writing paper ever produced, perhaps as early as 3000 B C.

The people of Egypt were spinning and weaving their cloths from plant fibres in Neolithic times. At first grasses were used, but during the First Dynasty the Egyptians began to weave with fibres from the flax plant. Linen was produced in an impressive variety of grades and colours, from materials as fine as silk to the coarsest canvas. Later they began to dye their cloths red, dark green, and even yellow with black spots to imitate leopard skin.

Grasses and rushes continued to be used for making baskets and mats.

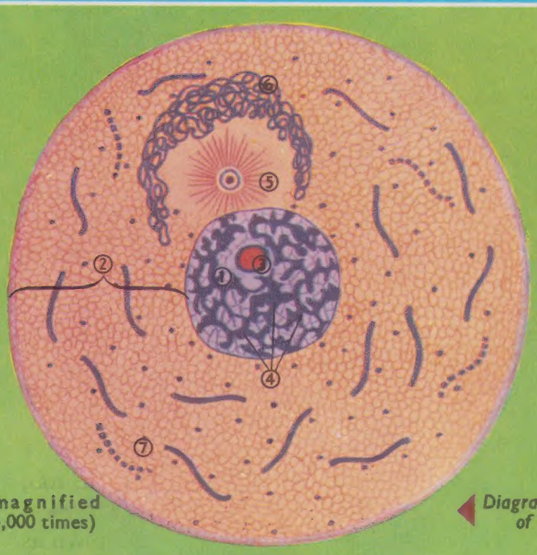
Model of an Egyptian granary found in a tomb
(Copenhagen Museum)

CONTROLLING THE NILE

Once the river had flooded it was important to hold back the waters for as long as possible so that they could soak well into the parched soil. The Ancient Egyptians used elaborate methods to achieve this result which is as important in modern times as it was then. Ever since the days of the first pharaoh, Menes (*c.* 3100 B C), dams have been built to retain the flood water as long as possible. The valley was divided into rectangular areas or basins, and for about a month each was filled with flood water to a depth of between 3 and 6 feet.

When the soil was saturated, the water was drained off into a basin at a lower level, and eventually back into the Nile. Where the flood water would not flow of its own accord, canals were built. If this entailed sending the water uphill, a chain of *shadufs* were used. A shaduf was rather like a giant spoon, which scooped up about half a gallon of water at a time and swung it into a trough above the river. It has been estimated that a shaduf could raise about 600 gallons of water 6 feet in one day.

THE ANIMAL CELL



(magnified 4,000 times)

Diagram of the structure of an animal cell

CELLS are packets of life. All living things are made of cells, from amoebae so small that they are only just visible to the naked eye, to the great blue whales of the southern oceans. The amoeba is minute, and is merely a single cell living independently of all others; the whale is a vast conglomeration of cells, each dependent upon its fellows.

As might be expected, the single cell of the amoeba is very different from those of the whale. Even two cells from different parts of the same whale are quite dissimilar. But underlying every living cell there is a plan which is common to all. This is the plan which enables the cell to live: to feed and to grow, to breathe, and, occasionally, to reproduce itself.

The common plan for cells is shown in the illustration at the top of this page. The picture is not an exact one of a particular cell but merely a diagram to show how the various parts of cells are arranged. The blue area in the middle is the *nucleus*, the centre from which the cell is controlled. Around it is the *cytoplasm*, a mass of material which contains several minute structures known as *organelles*, and which is thickened on the outside to form the *cell wall* or *cell membrane*.

THE NUCLEUS

The cell nucleus is made largely of a substance called *chromatin*. This material is distributed in fine filaments throughout the whole of the nuclear mass and gives the nucleus its characteristic dense appearance. Just before a cell divides, however, the chromatin collects into a relatively small number of quite large bodies called *chromosomes*. These structures can be seen quite clearly with an ordinary microscope.

The nucleus is surrounded by the *nuclear membrane*. This separates it from the cytoplasm but is not an absolute barrier, as it is pierced with a vast number of minute holes. Nutrients can pass from the cytoplasm into the nucleus, and substances formed in the nucleus can move out into the cytoplasm.

Lastly, inside every nucleus there is at least one small but prominent body called a *nucleolus*; often there are two or even three. It is thought that the nucleoli are intranuclear 'factories' in which cell protein and a substance called *ribose nucleic acid* are made.

THE CYTOPLASM

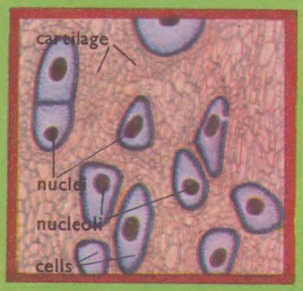
Throughout the cytoplasm of a cell there runs a complicated network of channels so small that they can be seen only in pictures taken with an electron microscope. This channel system is called the *endoplasmic reticulum*.

Many of the channels lead to the external surface of the cell, and it is thought that they are the routes along which food molecules reach the cell interior. Such an arrangement seems particularly convenient, for the endoplasmic reticulum is lined throughout with minute bodies called *ribosomes*. These are known to be the sites at which food is converted into the protein of which cells are largely made.

It is still a mystery how the channels of the endoplasmic reticulum are formed within the cytoplasm. Perhaps they are made inside the organelle known as the *Golgi body*. This structure was discovered over 60 years ago by the Italian biologist Camillo Golgi, but even today no function can be attributed to it with certainty.

In cells which are about to divide it is often possible to see two small structures called *centrosomes*. These organelles always lie close to the nucleus, for they form the poles to which the dividing halves of the chromosomes migrate during cell division.

More generally distributed through the cytoplasm are the *mitochondria*. The function of these small bodies is to perform the oxidation reactions which provide cells with their energy.

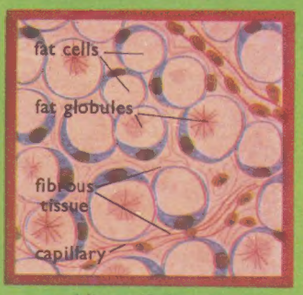


Cells in cartilage

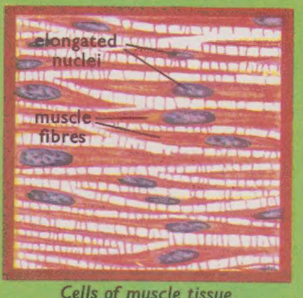
THE SHAPE OF CELLS

The single cell of the amoeba is remarkable in that, by itself, it serves all the animal's needs. In larger animals cells are specialised in groups to perform particular tasks. Though specialised cells function better than the single cell of the amoeba, they are only able to perform one task each.

A special task requires a special structure, and thus in multicellular animals there are cells of many shapes and sizes. In cartilage, for example, the task of the cells is to form cartilaginous tissue. The cells are conveniently spherical or ovoid in shape. In adipose (fat) tissue the task is to store fat, and again the cells are spherical, for each is distended by the fat globule that it contains. It is characteristic for the nucleus of a fat cell to be pushed over to one edge.



Adipose (fat) tissue



Cells of muscle tissue

Muscle cells are long and thin and thus excellently designed for their task of contraction. Nerve cells have long processes, the axon and the dendrons along which the nerve impulses travel.

In spite of these great differences in function and shape, however, all living cells have the same basic components. They are all constructed according to the single fundamental plan which enables them to live.

A nerve cell

Note: all these cells are greatly enlarged

THE PRE-RAPHAELITES

THE year 1848 was one of political revolutions on the continent of Europe. But in Britain it was the year of a different type of revolution – in art. In that year a group of young British painters decided to form a society called the Pre-Raphaelite Brotherhood. They were inspired by the works of painters who lived before the time of Raphael (see page 1994).

The Pre-Raphaelites painted a world in which the grass was greener, the sky bluer, and the people more beautiful than in real life. Nothing crude entered it. The attitudes of the people were completely unreal. Fairy-tale knights rode out to do battle for unbelievably beautiful girls. Monstrous dragons lurked among fantastic crags. Idyllic peasants romped in lush Arcadian pastures. In fact, the Pre-Raphaelites were completely out of touch with the realities of the times in which they lived.

Yet many of the best art galleries have examples of Pre-Raphaelite painting. Why? First because the men who painted these pictures were superb craftsmen; the technical excellence of the Pre-Raphaelite paintings is undoubted; you may not like the subject matter, but you will probably admire the way in which it is painted. Secondly, the Pre-Raphaelites are interesting historically as a product of their times – as part of the Romantic Movement. This movement has now been over for a long time, and because we are completely out of sympathy with it, it is not easy to appreciate the pictures that were painted under its influence. Moreover, at present the Pre-Raphaelites are out of fashion. Just as simple mediaeval art was not in vogue in the 18th century, and the formal, heavy painting of the 18th century was deprecated at the time of the Pre-Raphaelites, so today many people find the Pre-Raphaelites to be over-romantic.

What was the Romantic Movement of which the Pre-Raphaelites were a part, and which had such an effect on Victorian England? First, the Romantic Movement was a reaction against the 18th century. The art of the 18th century was inspired by that of classical times, but that of the Romantic Movement looked to the Middle Ages – before the time of Raphael. Whereas the writings of the 18th century were formal and often stilted, the Romantics wrote as they felt. Contrast the measured verses of the 18th-century poet Pope and the wild outpourings of the romantic Swinburne. The building of the Romantic period was a reaction, too. The Gothic Revival in architecture produced outlandish buildings like St Pancras Railway Station – a contrast to the stately magnificence of the classical architecture of the 18th century. In religion, too, there was a contrast – in the 19th century there was a revival of ceremonial and religious forms of the Middle Ages known as the 'Oxford Movement'. This was far removed from the religion of people in the 18th century, who disliked outward religious displays.

But not only was the Romantic Movement a reaction against the past, it was also a reaction against the present. In the middle of the 19th century a great pall of smoke hung over the larger towns of Britain in which great mills and factories, full of white-faced, unhappy people, roared day and night. The Romantic Movement was an escape from this world. In the

The Hireling Shepherd, *by William Holman Hunt, shows one of his favourite idyllic pastoral scenes* (City of Manchester Art Gallery; 1852)

The Morning of the Resurrection, *by Edward Burne-Jones; religious subjects were popular with the Pre-Raphaelites*
(Tate Gallery, London)

paintings of the Pre-Raphaelites there were no factory chimneys or power looms.

English painters were not the only ones to react against what they considered to be stilted, pompous painting. At the same time in France the Impressionists were also trying to paint in a fresher and more spontaneous style. Both the Pre-Raphaelites and the Impressionists tried to represent Nature accurately, but whereas the Pre-Raphaelites did this in fantastic detail, the Impressionists went to the opposite extreme. A Pre-Raphaelite picture of a cornfield would painstakingly reproduce individual blades of corn, an Impressionist one would simply be a flash of colour – the first impression the view made on the artist.

How it all began

In 1848 three artists, William Holman Hunt, then aged 21, Dante Gabriel Rossetti, aged 20, and John Everett Millais, aged 19, became very excited over some engravings of 15th-century Pisan wall paintings. They were by an Italian, Benozzo Gozzoli, who had lived 50 years before Raphael. These young artists were depressed by the studied mannerism and heaviness of the paintings that were being produced around them. They longed to escape from this artificiality and return to freshness and simplicity in painting. They felt that the Italian primitives like Gozzoli had this secret. They therefore decided to form a group to paint in the same spirit. The title they chose, the Pre-Raphaelite Brotherhood, was unfortunate, for it implied that they despised all painting from Raphael onwards. This, of course, was not true; Holman Hunt, for instance, greatly admired the work of the German painter Dürer.

The ideals of the Brotherhood were championed by two of the most respected figures in the art world – the designer William Morris and the art critic John Ruskin. But it did not last long. The idea of a secret society was exciting at first; it met to read Romantic poems by Keats, Browning, and Tennyson; it had a magazine called *The Germ*; and even took on a few pupils. But Rossetti soon broke away and the group disintegrated. Its ideas, however, continued to be influential, and Hunt at least remained faithful to them till the end of his life.

The Pre-Raphaelites greatly admired the high standard of craftsmanship of the early Renaissance painters. They especially loved their pure colours. These had been obtained by crushing rock and earth, and so the Pre-Raphaelites themselves mixed their own colours from elaborate recipes rather than buying them ready-made. As a result their colours were beautifully clear and vibrant.

Accuracy, both visual and historical, was, they felt, another sign of good craftsmanship. They copied nature minutely, right down to the smallest detail. Nothing was left to the imagination. They also went to tremendous lengths to make sure their pictures were factually 'honest'. Holman Hunt visited Palestine to find a genuine model for his *Scapegoat*.

They were anxious that the message of their paintings, usually a moral one, should be clear, and thus often made their pictures tell a story. Most of the early Italian artists whom the Pre-Raphaelites admired so much had painted religious themes. This was simply because the Church was their greatest patron. But the Pre-Raphaelites were not going to confine themselves like this; they felt that the nobler the subject, the more uplifting a picture would be. Thus they took many of their subjects from literature, ancient myths, legends, and the Bible.

The Blind Girl, *by John Millais; its brilliant colour is characteristic of his best work*
(Birmingham Art Gallery)

Ophelia, *by John Millais; its minute detail and glowing colours, as well as its literary theme, are typically Pre-Raphaelite* (Tate Gallery, London; 1852)

William Holman Hunt (1827–1910)

In 1854 Hunt painted his famous *Light of the World*, and this made his name. Everything in this picture is symbolic; the door at which Christ is knocking represents the human soul; the weeds are symbols of neglect; and the bat signifies ignorance. In the same year he left for Syria and Palestine to paint scenes from Scripture. *The Scapegoat*, a lonely animal standing on the shores of the Dead Sea, was followed by many other works of this type including *The Finding of Our Saviour in the Temple*, and the *Triumph of the Innocents*. Hunt was the most conscientious of the Pre-Raphaelites; he spent years perfecting each of his pictures, and was completely obsessed by accuracy.

John Everett Millais (1829–1896)

Millais defined the aim of the Pre-Raphaelites as 'to present on canvas what they saw in Nature', and indeed his first Pre-Raphaelite picture, *The Carpenter's Shop*, painted in 1850, provoked a storm of abuse as being too realistic. *The Huguenot* and *Ophelia*, however, helped to establish his reputation with the public, as did the enthusiastic support of John Ruskin. Ruskin's wife was his model in *The Order of Release*, and when their marriage was annulled Millais married her himself.

During the last 20 years of his life Millais abandoned his Pre-Raphaelite ideals and pandered to public taste, producing landscapes, pictures of children (often, as in *The Boyhood of Raleigh*, his own), and portraits (included among his sitters were Gladstone, Lord Tennyson, and Sir Henry Irving). He was elected President of the Royal Academy in 1896.

Dante Gabriel Rossetti (1828–1882)

Rossetti came from a very artistic family; his Italian father was a student of Dante, and his sister was the famous poetess Christina. He himself is as famous for his poetry as for his paintings, for both of which he often took Dante's *Divine Comedy* as his subject. Rossetti contributed some of his most famous poems to *The Germ*. *Ecce Ancilla Domini*, painted in 1850, is his greatest work in the Pre-Raphaelite spirit; he used his sister Christina as his model for the Virgin.

Hunt, Millais, and Rossetti all used the beautiful Elizabeth Siddal as their model in numerous pictures; she is Hunt's *Sylvia*, Millais' *Ophelia*, and Rossetti's *Beata Beatrix*. Rossetti married her in 1860, but she died two years later.

Rossetti drifted away from the Brotherhood, and turned his talents to decorative design; he played a large part in the revival of stained-glass painting as an art. *Paolo and Francesca* and *Dante's Dream* are his most famous later works. Rossetti's painting was far more romantic and imaginative than what is usually understood as Pre-Raphaelite.

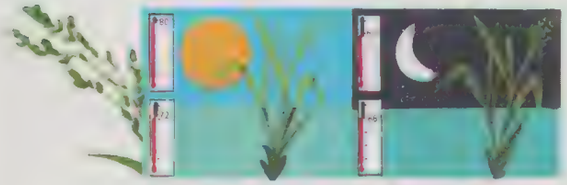
Edward Burne-Jones (1833–1898)

Though not one of the Brotherhood, Burne-Jones was an intimate member of the Pre-Raphaelite circle and was greatly influenced by Rossetti. *King Cophetua and the Beggar Maid*, painted in 1886, is probably his most famous painting, but he was far less influential as a painter than as a designer. He was an enthusiastic supporter of William Morris's campaign for decorative design, designing stained-glass windows for Morris and Co., and illustrating numerous books for the Kelmscott Press, founded by Morris in 1891.

The Annunciation, *by Dante Gabriel Rossetti; painted before he departed from the Pre-Raphaelite ideals* (Tate Gallery, London)

RICE

RICE is the main food of hundreds of millions of people in Asia, where 95 per cent of the world's rice crop is grown. On page 1284 we have given an account of rice from the economic point of view, and also of its history as a cultivated crop. In this article more details are given about the plant itself and its cultivation. The food value of rice depends mainly on its high content of easily digestible starch, but it also contains protein and a small amount of fat. There are vitamins in rice, but they are located in the outer coat of the seed; if this is removed by milling or 'polishing', a diet consisting mainly of rice will be found deficient. People who prefer to eat milled or white rice must include plenty of fresh vegetables in their diet, and if possible meat or fish as well. Even unmilled rice does not provide an adequate diet by itself, as its content of protein and fat is not high enough, and it does not contain all the vitamins essential to health.



Maximum and minimum temperatures in air and water during a summer day

The rice plant

Rice is generally grown in shallow standing water, although it was not originally an aquatic plant and will grow in ordinary soil. Besides providing an abundant supply of moisture, the water in which it is grown helps to keep the plant at a constant temperature. This is important because the plant is sensitive to great and rapid changes of temperature. In a warm temperate climate the air temperature in summer may rise to 80°F during the day and fall to 65° at night. In the same conditions the water in a rice field will vary only between about 68° and 72°F. This is illustrated in the diagram on the left.

Rice is really a kind of grass, with fine roots, a hollow stem, and narrow leaves. These have parallel veins and are covered with fine hairs.

Rice plant

Weeders at work clearing a rice field of

RICE FIELDS

Rice is grown in level fields; if the ground is sloping it must be terraced so that the fields can be flooded. A hot or warm temperate climate with plenty of rain is best for rice-growing. Grass or wheat can be grown in rotation with rice.

The fields are prepared for planting in the spring. First they must be made perfectly level; this is very important, as the plants must all be covered by the same depth of water. The fields are separated

Levelling the ground with a roller before sowing

The appearance of the rice fields before sowing by hand

Treatment of the field after sowing

Transplanting the young rice plants by machine

METHODS OF CULTIVATION

Rice can be sown in one of two ways. The seed can be sown very thickly in 'nurseries' and the young plants transplanted to the fields, or it can be sown broadcast, just as wheat is, and grows up where the seed falls. In America and Africa it is broadcast, but in Asia and in Spain and Italy the transplanting method is used. Much more work is needed for this method, but it has several advantages. During the period between harvesting the rice and planting out the next year's seedlings the ground can be put to some other use. The yield per acre is higher because the plants are correctly spaced, not overcrowded or too scattered, and also because unhealthy and undersized plants can be taken out and thrown away at the time of transplanting. There is less trouble from weeds because the young rice plants are put out in fields that are completely cleared of other plants, and they have a good start over any weed seeds that germinate afterwards. In Asia the sowing and transplanting are almost all done by

weeds (rushes, algae, and so on) in June

from each other by embankments of earth a yard wide and 1 or 2 feet high. They may be as much as 8 or 9 acres in extent; if they are larger than this it is difficult to control the water. Terraced fields on hillsides may have an area of only 100 to 200 square yards. When there are large numbers of small fields at different levels (as happens in hilly country) the flooding and draining of the fields is done by diverting streams. This is a highly skilled business, and has to be carefully supervised.

hand, but in southern Europe rice growing is largely mechanised, even the transplanting being done in some areas by machine (see pictures on the left).

In most of Asia the time of planting depends on rainy and dry seasons, which occur at different times of the year in different countries. In Italy sowing is done at the end of April, after the field has been flooded and the water well stirred up so that the particles of soil settle down and cover up the seeds. In early June the young plants are sorted and the healthy ones are transplanted in the flooded rice fields. By September or October the rice is ready to be harvested. The field is then drained and allowed to dry out, and the rice is cut, either by hand or with machines similar to those used to harvest wheat. The yield may be over 30 hundredweight per acre.

The rice goes through several processes before it is ready to be sold. The husk or hull is removed, and the rice is milled or refined to make it white. It may then be treated with oil or with talc and finely powdered glucose; this gives it a good appearance and helps to preserve it.

The flower or ear

The stem ends in an inflorescence of the type known as an *ear*, each ear consisting of a number of clusters or bunches. The bunches are made up of numbers of *spikelets* which form the actual flowers. As these develop and the seed swells, the ears become heavy and cause the stalks to bend down.

The flower consists of stamens and pistils (there are no petals or sepals) which are enclosed by two sheaths called the *palea* and *lemma*; at the base of each of these is a small scale-like structure called a *glume*.

The fruit or grain

The rice grain is a fruit of the type known to botanists as a *caryopsis*, which is characteristic of all the grass family (Gramineae).

It is enclosed in the palea and lemma, which dry and lose their green colour when the seed becomes ripe. The palea and lemma form the husk or hull which the harvesters remove by threshing.

CLASSIFICATION

Species: sativa
Genus: Oryza
Family: Gramineae (this includes all cereals and grasses)
Order: Glumiflorae
Class: Monocotyledoneae
Division: Angiospermae

Varieties of rice

Rice was known to the Chinese in 3000 B C. Like most plants which have been cultivated for a long time, *Oryza sativa* has developed many varieties, which differ not only in the size of the grain but also in the time of ripening and the flavour. There are more than a thousand varieties in India alone.

Basically, however, there are two main groups of rice: *aquatic* rice which is grown in lowland districts and *upland* or hill rice. They are not completely distinct, for many of the upland rices grow better in flooded fields, while some lowland rices in India only need to be flooded during the germination period. Rice can also be grouped into *early* and *late* varieties. In parts of India early varieties will ripen in four months, while late varieties will take nearly seven. In Thailand and also parts of India there is a kind of giant rice which reaches a height of 10 to 15 feet. A remarkable feature of this variety is that it appears to be able to grow taller as the level of the water rises. Thus in the many districts where the water level cannot be adequately controlled this strain is particularly valuable, as others would be submerged.

BENVENUTO CELLINI

Benvenuto Cellini (1500–1571), *the greatest goldsmith of his time*

FEW ever got the better of Benvenuto Cellini. He was a match for anyone who crossed his path – popes or princes, cardinals or cut-throats. Utterly shameless, notoriously conceited, and dangerously quick-tempered, he enjoyed nothing more than a battle of wits, or, better still, of swords. To stop short at murder would have seemed cowardice to him. His arrogance knew no bounds; no woman was allowed to resist his charms. He saw himself as the bravest of fighters, the most ardent of lovers, and the most honest of men. Yet history has not condemned him; for this swaggering rascal happened also to be the greatest goldsmith in the world and has left us one of the most fascinating and lively autobiographies ever written. He was one of the most picturesque 16th-century characters, and one of the most skilled of Renaissance craftsmen.

CELLINI MAKES HIS NAME

Cellini was born in Florence in 1500, the son of a maker of musical instruments. Papa Cellini wanted to turn his son into 'the greatest musician in the whole world', but Cellini thought music 'a despicable art compared with the one I was set on', for he was determined to be a goldsmith from a very early age. At 15 he apprenticed himself to a Florentine goldsmith, and at 19, finally exasperated with having to practise his scales, he set out on foot to seek his fortune in Rome. He was not disappointed. His first job there was to make a silver salt-cellar for a cardinal; this was so successful that the shop master 'went round boasting and showing it off to all the other goldsmiths'. Cellini soon had a shop of his own and commissions poured in: a silver vase for the Bishop of Salamanca; gold badges for a nobleman's hat; and elaborate daggers. His confidence in himself grew, and he writes in glowing terms of the high position he held in public esteem.

Cellini had a generous nature. His success now enabled him to keep his father; and during his life not only did he support a widowed sister with six children, he also befriended another family as well as a series of art students and models.

A GREAT CRAFTSMAN

Although praise was heaped upon Cellini in his own day, today he is more famous for his autobiography than for his art. But despite all his romantic exploits, it was his art which Cellini really cared about. He was a very hard worker, and had a tremendous pride in good craftsmanship. Nothing excited him more than the challenge of a really difficult piece of work. Some of his sculpture lacks strength, but his smaller works are exquisitely detailed and intricate.

Casting the Perseus. This was a very dramatic and difficult undertaking; to stop pewter plates and bowls into the furnace. This

The fabulous golden salt-cellar commissioned by Francis I in 1540. The figure on the left holding the trident represents the Sea; that on the right the Land (Imperial Museum, Vienna)

ROMAN ADVENTURES

In 1527 Rome was besieged by forces of the Emperor Charles V. As Rome was sacked, Cellini rocketed to fame. At least that is what he says. 'If I told in detail the great things I did in that cruel inferno, I would astonish the world', he wrote; even so, Cellini manages to convey that he was the mainstay of the Roman defence. He claims it was he who killed both the French commanders, the Duke of Bourbon and the Prince of Orange. Maybe he did. His manipulation of the swivel gun on the mighty Castel Sant'Angelo brought Pope Clement VII himself out to watch. All thoughts of art were 'forgotten in the music of the guns'.

Cellini became well established in the Pope's favour as a result of these services; he was made coiner of the Vatican mint, and noble dignitaries of the Church flocked to order ornaments, jewel-

lery, and chalices. But work for the Church was not his only occupation; once he downed tools to follow a pretty Sicilian girl all the way to Naples. And when in 1529 someone killed his brother in a street brawl, Cellini 'took to watching this man as though he had been the girl I was in love with'. He came upon him in a dark alley one night and killed him.

Cellini made many enemies; in 1537 one of these got him arrested on a trumped-up charge of stealing the jewels from the Papal tiara during the war. Cellini was thrown into prison 'where', he grimly relates, 'my death was resolved on'. He gives an amusing account of the prison warden. The man, he asserts, was mad. 'Every year his delusions took a different form; one year he imagined that he was an oil jar; another year he thought he was a frog; another time he was convinced that he was dead and they had to bury him. This time he began to imagine

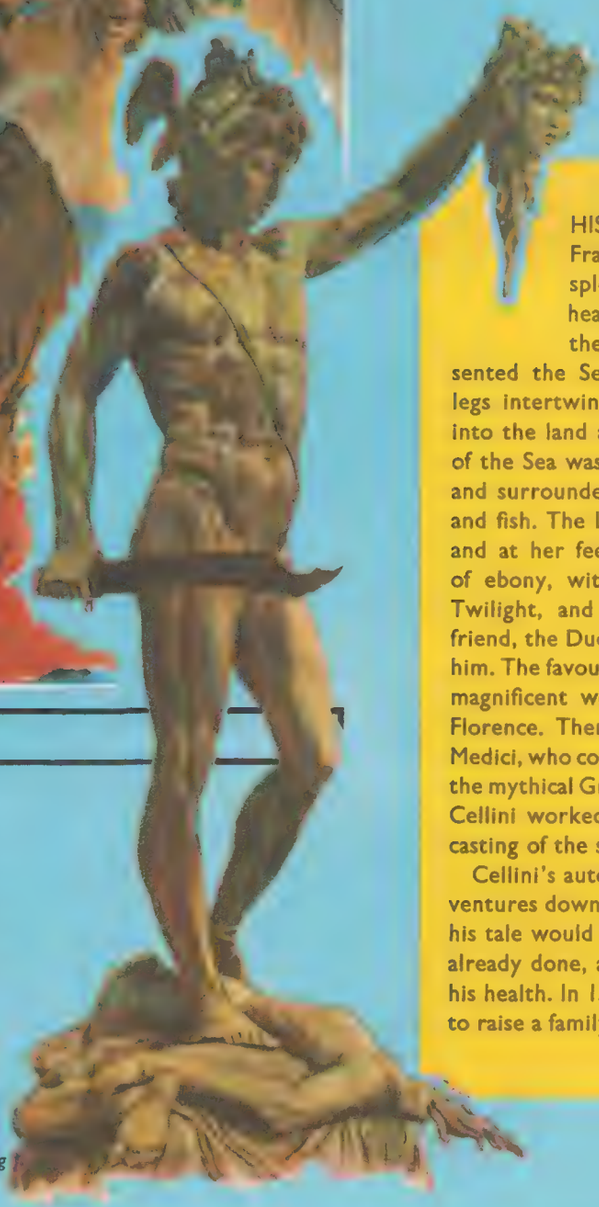
Cellini was at his best in small detailed works like the medal for Pope Clement VII (National Museum, Florence) *and the embossed shield* (Royal Armoury, Turin), *shown here*

he slipped out of his cell and down the knotted strips of sheet, but unhappily he fell and broke his leg and was then set upon by mastiffs. A passing servant rescued him and took him back to his master. But as bad luck had it this man was a cardinal who was trying to persuade the Pope to grant a bishopric to a friend of his. The Pope agreed to grant the bishopric if Cellini was handed over. Back he went to the dungeons and remained there, delirious, for days.

But away at Fontainebleau Francis I had let it be known that he would welcome the famous Benvenuto Cellini at his court; so Cellini exchanged his prison cell for the most brilliant court in Europe.

the metal curdling Cellini says he threw about 200 *bronze statue was Cellini's last great work*

he was a bat . . . and said that if Cellini flew away they should let him go too because he would be able to fly better by night and so would be able to catch him up.' Cellini began to plot his escape; he cut up his bed linen and stuffed it in his mattress, then he extracted the nails from the door hinges, refilling the holes with wax and dust. When all was ready



The bronze statue of Perseus triumphantly holding up the head of Medusa (Florence)

HIS FINEST YEARS

Francis treated him handsomely. He was given splendid apartments and commissions were heaped on him. The King himself commissioned the famous golden salt-cellar. 'This represented the Sea and the Land, both seated with their legs intertwined just as some branches of the sea run into the land and the land juts into the sea.' The figure of the Sea was beside a ship which was to hold the salt, and surrounded with blue-enamelled waves, sea horses, and fish. The Land held a temple to contain the pepper, and at her feet were animals and rocks. The base was of ebony, with gold figures representing Night, Day, Twilight, and Dawn. But Cellini offended the King's friend, the Duchesse d'Étampes, who set the King against him. The favours were withdrawn, and after five years of magnificent work Cellini retired in 1545 in disgust to Florence. There he worked for the Duke Cosimo de' Medici, who commissioned him to make a statue of Perseus, the mythical Greek hero who slew the monstrous Medusa. Cellini worked at this for nine years, and his successful casting of the statue was his greatest artistic triumph.

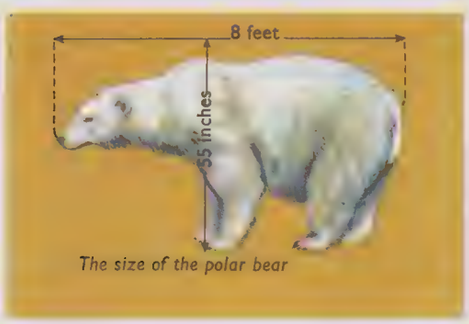
Cellini's autobiography only brings the story of his adventures down to 1562. But probably had he continued it his tale would have been one of woe; his best work was already done, and his strenuous life had begun to tell on his health. In 1564 he married his housekeeper and began to raise a family. In 1571 he died of pleurisy.

THE POLAR BEAR

A SEAL climbs out of the water on to the ice somewhere in the Arctic Ocean. It has been swimming under water for a long time, hunting for fish, and it is tired; perhaps for this reason it is not so alert as it should be. So far as it can see, everything around it is white – the white of ice and snow. Everything seems safe. It settles down to rest and breathes deeply after its dive.

Suddenly a part of the whiteness nearby seems to detach itself from the scene and moves towards the seal with terrifying speed. The poor creature plunges back towards the water, where it would be safe, but it is too late. A great paw armed with claws like hooks of steel drags it back; a blow from the other paw stuns it, and in a few moments it is dead. Yet another seal has fallen a victim to a prowling polar bear.

Most of the Arctic land mammals change the colour of their fur to white in winter, but the polar bear remains white all the year round. It always lives on or near the drift-ice; and the white camouflage that the hares and foxes of the far north put on only in winter serves the polar bear during the whole of its life.

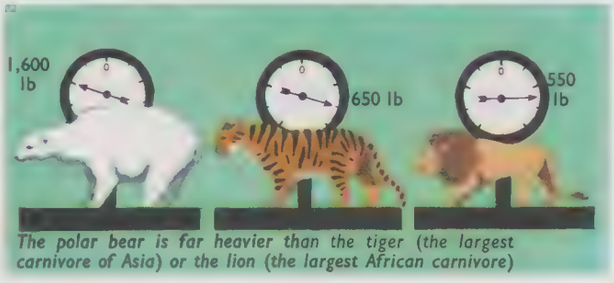


The size of the polar bear

Introducing the polar bear

The polar bear (*Thalarctos maritimus*) shares with the Kodiak bear of Alaska the distinction of being the largest of all carnivorous land animals now living. Zoologists are not entirely in agreement as to which of them is the bigger. A polar bear can grow to 8 feet in length (plus 6 or 7 inches of tail), and stand only a little short of 5 feet high at the shoulder; it can weigh as much as 1,600 pounds. You get a good idea of its size by comparing it with a tiger (about 650 pounds) or a lion (about 550 pounds).

Young polar bears are pure white, but their fur turns to creamy or yellowish white when they are adult. To the human eye a full-grown polar bear shows up quite clearly against the snow. The fur is very thick, and a layer of fat under the skin keeps the polar bear warm when it is swimming in the icy Arctic sea, which it often does for hours at a time.



The polar bear is far heavier than the tiger (the largest carnivore of Asia) or the lion (the largest African carnivore)

A scene of violence in the Arctic. A seal has climbed on to the ice after swimming and diving in search of fish, and is stalked and seized by a polar bear

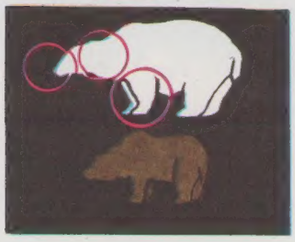


Diagram showing the difference in size and shape between the polar bear and brown bear

Where it lives

Geographical range of the polar bear

The polar bear inhabits the whole of the Arctic region and is probably most common along the north and east coasts of Greenland. It is also found on the Arctic coasts of North America and Asia, and bears occasionally travel on floating drift-ice to Iceland and the north of Norway, but they are rarely seen south of latitude 55°, which is the latitude of central Canada.

Polar bears are not, of course, found in the south Polar or Antarctic regions. The reason why penguins, which do inhabit the Antarctic (see page 1703), are so completely fearless on land is that there are no predatory animals living on land on the Antarctic continent or the nearby islands. So if you ever see a picture in which polar bears and penguins are shown together in the wild state you will know that someone has made a bad mistake.

What it eats

The polar bear is more completely carnivorous than any of the other bears, and this is to be expected, because the supply of vegetable food is very limited in the icy wastes which are its home.

Seals form its chief prey, and the bears are very clever at stalking them as they lie on the ice. If a bear sees a seal resting on the ice near the water's edge it will sometimes cautiously enter the water and swim, with only the tip of its nose above the surface, to where the seal is lying. The seal's only retreat is to the water, and if its enemy comes out of the sea it has no means of getting away. The only animals of the Arctic that the bear does not attack are the walrus and the musk ox. Musk oxen move about in herds and, fighting together, are quite capable of keeping a bear off; the walrus is too big and formidable for even a polar bear to think of attacking it. An old bull walrus will attack a polar bear and drive it away if it finds it in the water. And polar bears never try to hunt in the water, as seals are far better swimmers and can easily escape.

In the summer they do eat a certain amount of berries and grass, and will plunder the nests of birds such as ducks and gulls, and hunt the little Arctic rodents called lemmings. They are also quite ready to feed on the remains of dead whales and fish.

ITS WAY OF LIFE

Unlike the brown and grizzly bears, the polar bear has no period of hibernation, and the males only make dens in the snow for short periods, to shelter from snow-storms or to digest a particularly large meal. They wander all through the year, following the seals in their migrations and preying on any other animals that they can catch.

Polar bears appear heavy and clumsy in their movements, but they are really extremely active and can run fast enough to overtake a man quite easily. Their hairy feet give them an excellent grip on smooth ice, and their great wide paws enable them to travel faster and more easily in deep snow than any other animal. They are good climbers, too, and can scramble up the steep side of an iceberg or among the crevasses of a glacier.

Polar bears are often carried many miles from land on the floating drift-ice, but their strength and endurance in the water nearly always enable them to reach the shore.

POLAR BEARS AND MAN

The early stories of expeditions to the Arctic contain many accounts of the terrible ferocity of polar bears. These travellers' tales exaggerate the matter, but the male polar bear can be dangerous. The trouble is not so much that they are savage, but that they are extremely inquisitive. If a bear sees a man it approaches him out of pure curiosity; if he runs away or shouts for help the bear will become excited and strike him down. It is as well to be armed when on foot in the Arctic, but a great pity to shoot these fine animals unless one has to in self-defence.

BREEDING HABITS

Polar bears mate in April, and this is the only time of year when two adults are seen together. In January or February the female makes a hole in the snow near the shore, with a roomy chamber at the end; in this den she has her young. The newly born cubs are extremely small, only a little larger than a rat, and they are quite blind and helpless for two weeks. Two cubs may be born together, but often there is only one, and litters of three are very rare. The cubs live in the den until they are at least a month old. During this time the mother never leaves them, and so she gets no food herself, although she is suckling her young all the time. They stay with their mother, learning to hunt, for rather over a year.

Sectional view of the den occupied by the female polar bear and her cubs

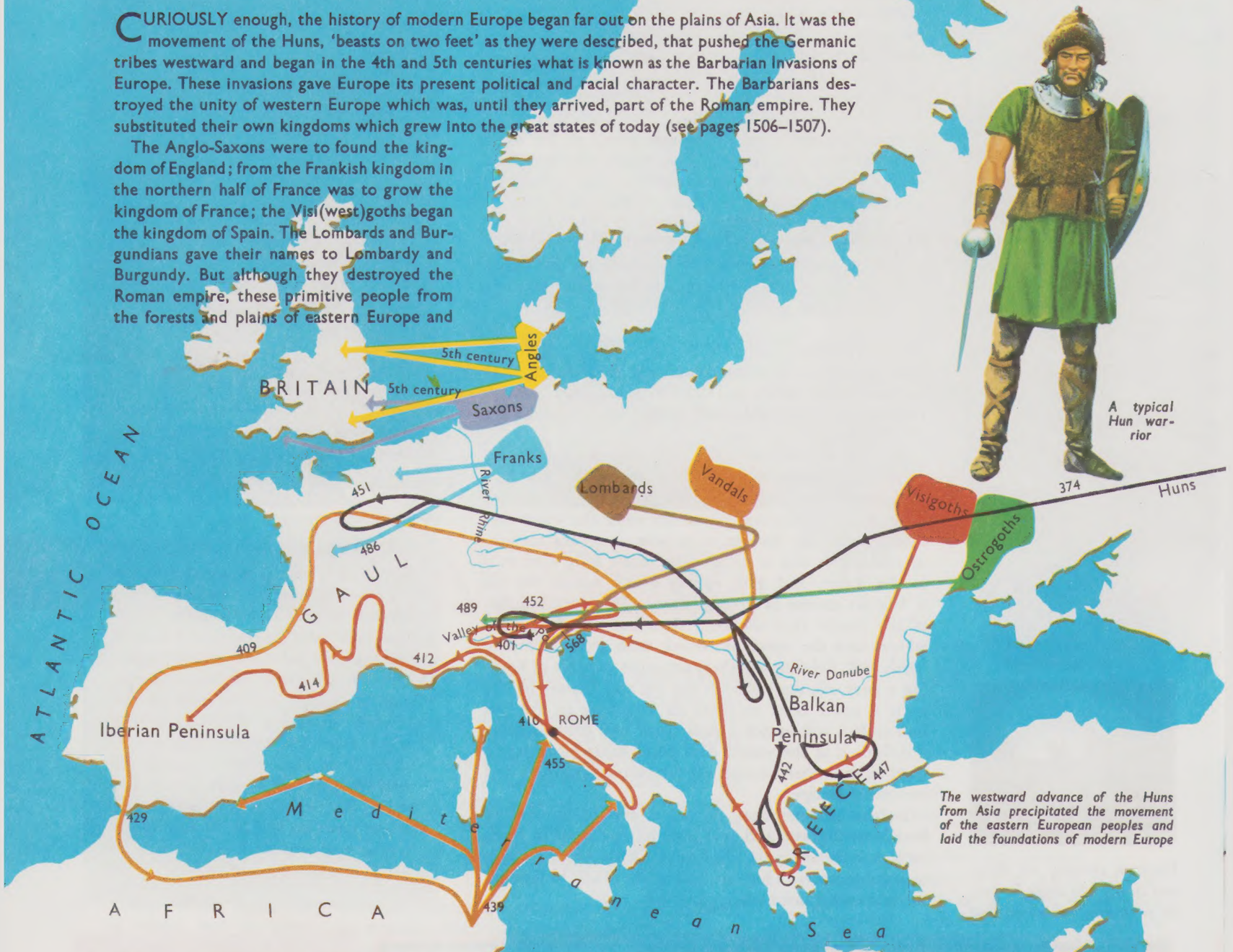
Length:	8 feet
Height at shoulder:	55 inches
Weight:	1,600 lb
Senses:	Hearing, sight, and smell all acute
Character:	Solitary, hardy, and inquisitive
Number of young:	One or two at a time
Habitat:	All over the Arctic regions

THE BARBARIAN INVASIONS SIMPLIFIED

CURIOUSLY enough, the history of modern Europe began far out on the plains of Asia. It was the movement of the Huns, 'beasts on two feet' as they were described, that pushed the Germanic tribes westward and began in the 4th and 5th centuries what is known as the Barbarian Invasions of Europe. These invasions gave Europe its present political and racial character. The Barbarians destroyed the unity of western Europe which was, until they arrived, part of the Roman empire. They substituted their own kingdoms which grew into the great states of today (see pages 1506–1507).

The Anglo-Saxons were to found the kingdom of England; from the Frankish kingdom in the northern half of France was to grow the kingdom of France; the Visi(west)goths began the kingdom of Spain. The Lombards and Burgundians gave their names to Lombardy and Burgundy. But although they destroyed the Roman empire, these primitive people from the forests and plains of eastern Europe and Asia were affected by the Roman civilisation. Although at first they came as plunderers, their rulers soon adopted the Christian religion and Roman titles.

A typical Hun warrior



The westward advance of the Huns from Asia precipitated the movement of the eastern European peoples and laid the foundations of modern Europe

But the Roman empire did not succumb to the Barbarians without a fight. In 451 the Huns were defeated in northern France and soon after passed from European history. In the next century, in a great counter-offensive by the eastern Roman empire, the Ostro(east)gothic state in Italy was wiped off the map, as was the Vandal state in Carthage. The Romans were helped by the quarrels among the Barbarians; for example, the Visigoths fought with the Romans against both Huns and Vandals.

The Barbarians mainly influenced northern Europe, which today is predominantly Germanic. In southern Europe the Barbarian influx did not really change the character of the people. The Ostrogoths and Visigoths who settled in southern Europe adopted the Arian religion, an offshoot of Christianity. Many of the original inhabitants of their kingdoms were Catholics and the invaders found it difficult to gain their support. The Vandals in North Africa were also Arians and their kingdom, like the kingdoms of the other two, was to disappear. The Franks and Anglo-Saxons both became Catholic and their kingdoms have remained.

The Barbarians have the name of destroyers – 'Hun' and 'Vandal' are sometimes used as terms of abuse. In the 5th century the Roman empire was already in decline and the Barbarian Invasions plunged Europe into the Dark Ages. But the Barbarians did not only destroy – they also absorbed much of the Roman culture which, mixed with the vigour of the Barbarians, gave European civilisation its unique character.

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THE SUPER-MYSTÈRE – 180 aircraft of this type have been built for the French Air Force. The single SNECMA Atar 101 G turbojet develops 9,700 pounds of thrust and with afterburning can provide a maximum speed of 745 miles an hour. (*For illustration, see previous page*).

The offensive armament of the Super-Mystère is varied and may consist of air-to-ground rockets, conventional bombs, napalm, or Matra air-to-air guided missiles. The flight endurance is 1 hour.

Five modern civil aircraft

THE COMET 4 – This four-engined airliner is the direct descendant of the ill-fated de Havilland Comet 1, the first jet airliner to go into service. It is powered by four Rolls-Royce Avon engines buried in the wing roots.

Although small in comparison with the big jets, the Comet 4 is capable of stage lengths up to 3,000 miles. A short-range version, the Comet 4B, is easily distinguished by the absence of wing nacelle fuel tanks. This modification, combined with the buried engine design, gives the 4B a particularly uncluttered appearance which makes it perhaps the most beautiful airliner ever to have flown.

THE CARAVELLE – Named after a type of fast sailing ship, this airliner was the first with rear-mounted engines. In consequence it was necessary to fit the tail-plane on the fin in order to keep it and the elevators out of the jet efflux. This minor difficulty, however, is outweighed by the low drag of the 'clean' wing, and the ease of asymmetric flying should one of the engines fail. An additional advantage of rear-mounted engines is the low noise level in the cabin.

Several different production models of this aircraft have been made. Almost all are powered by Rolls-Royce Avon engines.

THE TUPOLEV TU 114 – Although turboprop airliners cannot compete with turbojets in speed, they are, under certain conditions, much less expensive to fly. Furthermore they are far less noisy. Russian aircraft designers were doubtless well aware of these features of the turbo-prop engine when they chose four Kuznetsov NK 12 M engines with eight-bladed contra-rotating airscrews to power the largest airliner the world has ever seen.

The vast TU 114 has a wing span of 177 feet 2 inches, a length of 154 feet 10 inches, and is 38 feet 8½ inches high. It carries a crew of 10 to 15 and up to 220 passengers seated 8 abreast. The range is 6,200 miles at an economic cruising speed of 460 mph.

THE VC10 – This aeroplane is the first of the large 'second generation' passenger jets. As such its design includes many of the ideas suggested during the operation of its 'first generation' predecessors. The four engines are Rolls-Royce Conway by-pass turbojets.

THE BOEING 707 – The first of the large jets to go into airline service, the 707 is one of the most popular aircraft ever offered to airline operators. Indeed it approaches the successes enjoyed by the DC3 and the Viscount.

The production of 707s in unusually large numbers has enabled the manufacturer to make many improvements and modifications to suit the needs of individual operators, and as a result there are now several versions of the basic design.

One important modification has been the substitution of Rolls-Royce Conway engines for the American Pratt and Whitney JT3s in many of the aircraft purchased by operators who are short of dollars.

In civil aircraft jet engines reduce the duration of each journey. A single aircraft can thus make more flights, and in consequence the fares can be reduced

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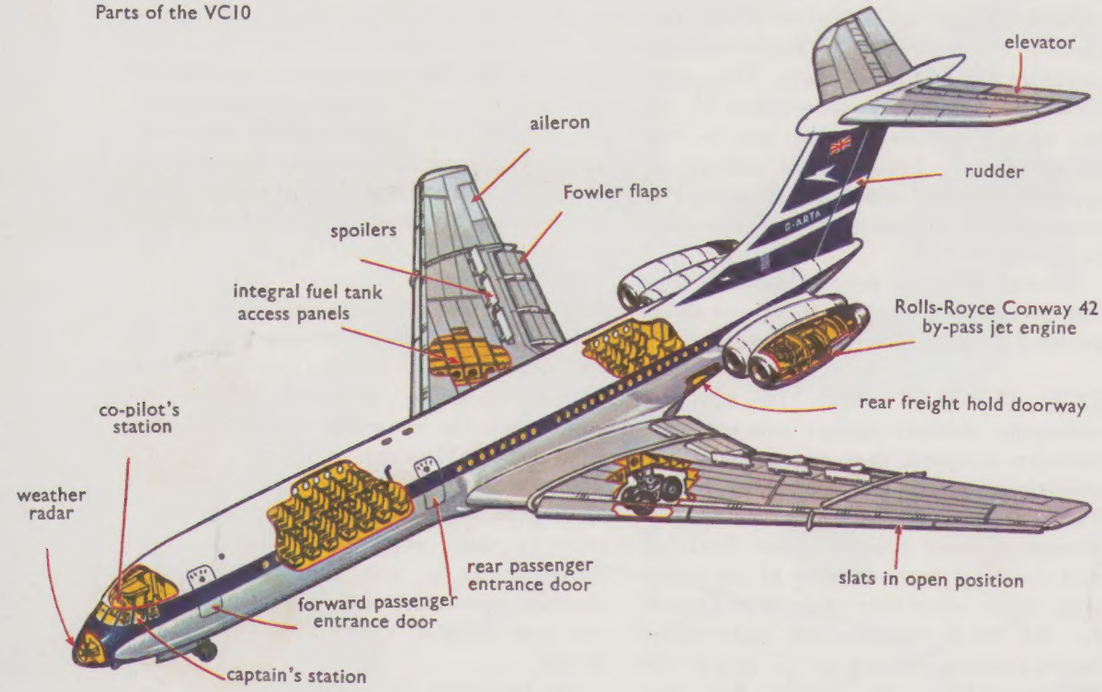
Parts of the VC10



The parts of an airliner

Conventional airliner design provides a large *fuselage* for carrying passengers, freight, and crew. It is supported in the air by the *wings*, and by the *tail-plane*, and lateral stability is provided largely by the vertical *fin*. The engines may be mounted in the wing roots, in *pods* beneath the wings, or beside the rear part of the fuselage. When on the ground the aircraft stands on a tricycle undercarriage consisting of a *main landing gear* unit under each wing root, and a *nose-wheel*. This gear is retracted in flight.

To the trailing (rear) edge of each wing are attached two structures, the *ailerons* and the *flaps*. The ailerons hinge up and down and are used to tilt the aircraft sideways during turning manœuvres. The flaps are movable extensions of the wing surfaces used to increase lift at low speeds. Even more lift may be obtained by means of the adjustable *slats* fitted along the wings' leading edges. Above the wings are the *spoilers*, or air brakes, used to reduce speed when landing.

At the rear the *elevators* are fitted to the trailing edge of the tail-plane, and the *rudder* to the trailing edge of the fin.

How an aeroplane flies

The purpose of an aero-engine is to move the aircraft of which it is part in a forward direction. In a piston or turboprop engine the propeller blades push a stream of air forcibly backwards, and, because in this process the air pushes equally forcibly on the rear surfaces of the blades, the whole aircraft moves forwards. In a turbojet engine it is the turbine which creates this forward thrust.

Once the aircraft begins to move, air flows over and under the wings. Now the shape of the wings and the angle at which they are set are so arranged that air passing *over* them moves faster than that passing beneath. It therefore presses less strongly on the upper wing surface. Consequently there is relatively more air pressure on the undersurface of the wing than on its upper surface, and it is this upward pressure which lifts the wing, and the aircraft, off the ground.

Directional control is achieved by the elevators, the rudder, and the ailerons. When the control column is pulled back the elevators hinge upwards, the tail drops, and the aircraft climbs. When the column is pushed forwards the elevators hinge downwards and a dive begins.

Lateral control is brought about by the rudder. Aeroplanes, however, side-slip if controlled by the rudder alone, and so ailerons are provided to tilt the aircraft in the direction of turn. In a right turn the right aileron hinges upwards and the left downwards. The aircraft banks to the right, and movement of the rudder to the right will then bring about a right turn with side-slip.

Diagrams showing how the wing imparts lift, and how the direction of an aeroplane is controlled as it flies through the air